

TITLE OF THE INVENTION

Organic Film Vapor Deposition Method and A  
scintillator panel

RELATED APPLICATIONS

5           This is a Continuation-In-Part application of  
International Patent Application serial No. PCT/JP99/03269  
filed on June 18, 1999 now pending.

BACKGROUND OF THE INVENTIONField of the Invention

10           The present invention relates to an organic film vapor  
deposition method for depositing a moisture-resistant  
protective film onto a scintillator panel for medical X-ray  
photography or the like and the scintillator panel made by  
this method.

15           Related Background Art

          While X-ray sensitive films have been used in medical  
and industrial X-ray photography, radiation imaging systems  
using radiation detecting devices have been coming into wider  
use from the viewpoint of convenience and their storability  
20           of photographed results. In such a radiation imaging system,  
pixel data caused by two-dimensional radiation are acquired  
by a radiation detecting device as an electric signal, which  
is then processed by a processing unit, so as to be displayed  
onto a monitor.

25           Conventionally known typical radiation detecting  
devices include those disclosed in Japanese Patent

Application Laid-Open No. HEI 5-196742 and No. SHO 63-215987.  
Such a radiation detecting device forms a scintillator on  
an imaging device or FOP, such that the radiation incident  
thereon from the scintillator side is converted by the  
scintillator into light, so as to be detected.

Here, CsI, which is a typical scintillator material,  
is high in moisture absorbency and deliquesces by absorbing  
vapor (moisture) in the air, thereby deteriorating  
characteristics of the scintillator such as the resolution  
in particular. Therefore, a moisture-resistant barrier  
impermeable to water is formed on the upper side of the  
scintillator layer in the above-mentioned radiation  
detecting device, so as to protect the scintillator against  
the moisture.

While a polyparaxylylene film or the like is in use  
as the moisture-resistant barrier for protecting the  
scintillator against the moisture, this polyparaxylylene  
film is deposited by CVD method (vapor phase growth method).  
When depositing a polyparaxylylene film by CVD method, a  
planar vapor deposition table or meshed vapor deposition  
table in a state where a substrate formed with a scintillator  
is mounted thereon is put into a vapor deposition chamber  
of a vapor deposition apparatus, whereby the  
polyparaxylylene film is deposited.

#### SUMMARY OF THE INVENTION

When the polyparaxylylene film is deposited by the

above-mentioned method, however, the polyparaxylylene film is formed not only on the substrate but also on the vapor deposition table, whereby the substrate is harder to take up from the vapor deposition table, and it has been impossible  
5 for the polyparaxylylene film to be formed over all surfaces of the substrate formed with the scintillator.

It is an object of the present invention to provide an organic film vapor deposition method for depositing an organic film for protecting a scintillator panel onto all  
10 surfaces of a substrate formed with a scintillator.

The present invention is characterized in that it comprises a first step of supporting a substrate formed with a scintillator on at least three protrusions of a target-support element disposed on a vapor deposition table  
15 so as to keep a distance from the vapor deposition table; a second step of introducing the vapor deposition table having the substrate supported by the target-support element into a vapor deposition chamber of a CVD apparatus; and a third step of depositing an organic film by CVD method onto  
20 all surfaces of the substrate, provided with the scintillator, introduced into the vapor deposition chamber in a state that said substrate is supported so as to keep a distance from said vapor deposition table.

According to the present invention, since the  
25 substrate is supported away from the vapor deposition table by the target-support element disposed on the vapor

deposition table, the organic film can also be deposited onto the underside of the substrate supported by the sample support, whereby the organic film can be deposited on all surfaces of the substrate including the scintillator by CVD method. Also, the substrate can easily be taken up from the vapor deposition table after the organic film is deposited thereon.

The target-support element of the present invention is characterized in that it is constituted by at least three target-support needles. Also, the target-support is characterized in that it is constituted by a strand member.

Also, the present invention is characterized in that the organic film in the organic film vapor deposition method is a polyparaxylylene film. According to the present invention, the polyparaxylylene film can be deposited on all surfaces of the substrate provided with the scintillator by CVD method.

A scintillator panel according to the present invention having organic film deposited by the above-mentioned method.

This scintillator panel comprises a substrate, a scintillator formed on the substrate, and an organic film covered substantial all surfaces of the substrate not only over the scintillator side but also over the opposite side. This scintillator panel has good moisture-resistant performance.

The present invention will be more fully understood from the detailed description given hereinbelow and the accompanying drawings, which are given by way of illustration only and are not to be considered as limiting the present invention.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will be apparent to those skilled in the art from this detailed description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of a polyparaxylylene vapor deposition apparatus in accordance with an embodiment of the present invention;

Fig. 2 is a schematic view of the vapor deposition chamber in the polyparaxylylene vapor deposition apparatus in accordance with an embodiment of the present invention;

Fig. 3 is a view showing a state where a substrate is supported on a turntable of the polyparaxylylene vapor deposition apparatus in accordance with an embodiment of the present invention;

Fig. 4A is a view showing a manufacturing step of a

scintillator panel in accordance with an embodiment of the present invention;

Fig. 4B is a view showing a manufacturing step of the scintillator panel in accordance with an embodiment of the present invention;

Fig. 5A is a view showing a manufacturing step of the scintillator panel in accordance with an embodiment of the present invention;

Fig. 5B is a view showing a manufacturing step of the scintillator panel in accordance with an embodiment of the present invention; and

Fig. 6 is a modified example of sample support in accordance with an embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, a polyparaxylylene film (organic film) deposition method in accordance with an embodiment of the present invention will be explained with reference to the drawings. Fig. 1 is a diagram of a polyparaxylylene vapor deposition apparatus used in the polyparaxylylene film vapor deposition method.

This polyparaxylylene vapor deposition apparatus comprises a vaporization chamber 1 for receiving and vaporizing diparaxylylene which is a material for polyparaxylylene; a thermal decomposition chamber 2 for heating vaporized diparaxylylene to a higher temperature so as to form a radical therefrom; a vapor deposition chamber

3 for depositing diparaxylylene in a radicalized state onto a substrate formed with a scintillator; a cooling chamber 4 for deodorizing and cooling; and an exhaust system 5 having a vacuum pump. Here, as shown in Fig. 2, the vapor deposition chamber 3 has an inlet 3a for introducing polyparaxylylene radicalized in the thermal decomposition chamber 2 and an outlet 3b for discharging an excess of polyparaxylylene, and also has a turntable (vapor deposition table) 3c for supporting a target onto which a polyparaxylylene film is to be deposited.

First, in the polyparaxylylene vapor deposition apparatus, a disk-shaped or rectangular sheet-like substrate 10 formed with a scintillator 12 is supported on the turntable 3c of the vapor deposition chamber 3 by target-support needles 20. Namely, as shown in Figs. 2 and 3, the bottom face of substrate 10 is supported by three target-support needles 20 disposed so as to form a substantially equilateral triangle, and is disposed on the turntable 3c. These three target-support needles 20 constitute a target-support element. Here, each target-support needle 20 has a pointed target-support portion 20a at one end and a disk-shaped base portion 20b, in contact with the upper face of the turntable 3c, at the other end. In the substrate 10 formed with the scintillator 12, as shown in Fig. 4A, columnar crystals of CsI doped with Tl are grown by a thickness of 250  $\mu\text{m}$  by a vapor deposition

method on one surface of the disk-shaped or rectangular sheet-like substrate 10 (having a thickness of 0.5 mm) made of Al, so as to form the scintillator 12.

Subsequently, the turntable 3c, on which the substrate 10 formed with the scintillator 12 is disposed, is introduced into the vapor deposition chamber 3, whereas diparaxylylene heated to 175 °C and vaporized in the vaporization chamber 1 and then heated to 690 °C and radicalized in the thermal decomposition chamber 2 is introduced into the vapor deposition chamber 3 from the inlet 3a, whereby a first polyparaxylylene film 14 is deposited on all surfaces of the scintillator 12 and substrate 10 by a thickness of 10 μm (see Fig. 4B). Namely, since the substrate 10 formed with the scintillator 12 is supported only by the tip parts of target-support portions 20a of the target-support needles 20 on the turntable 3c, the first polyparaxylylene film 14 can be deposited not only on the surfaces of scintillator 12 and substrate 10, but also on the underside of the substrate 10 and the like.

In this case, the inside of vapor deposition chamber 3 is maintained at a vacuum of 13 Pa. On the other hand, the turntable 3c is rotated at a speed of 4 rpm so that the first polyparaxylylene film 14 is uniformly deposited. The excess of polyparaxylylene is discharged from the outlet 3b, so as to be led into the cooling chamber 4 for deodorizing and cooling and the exhaust system 5 having a vacuum pump.



Subsequently, the substrate 10 having the first polyparaxylylene film 14 deposited thereon is taken out of the vapor deposition chamber 3, and an  $\text{SiO}_2$  film 16 is formed on the first polyparaxylylene film 14 on the scintillator 12 side with a thickness of 300 nm by sputtering (see Fig. 5A). Since the  $\text{SiO}_2$  film 16 is aimed at improving the moisture resistance of scintillator 12, it is formed in an area covering the scintillator 12.

Further, a second polyparaxylylene film 18 is deposited with a thickness of 10  $\mu\text{m}$  again by CVD method on the surface of  $\text{SiO}_2$  film 16 and the surface of first polyparaxylylene film 14 not formed with the  $\text{SiO}_2$  film 16 on the substrate 10 side (see Fig. 5B). Namely, the substrate 10 is supported by the three target-support needles 20 on the turntable 3c of the vapor deposition chamber 3 in this case as well in a manner similar to that at the time when the first polyparaxylylene film 14 is deposited. That is, in a manner similar to that at the time when the first polyparaxylylene film 14 is deposited, the bottom face of substrate 10 is supported by the three target-support needles 20 disposed so as to form a substantially equilateral triangle, and is disposed on the turntable 3c (see Figs. 2 and 3). In this case, the substrate 10 is supported such that the position at which the substrate 10 is supported by the target-support needles 20 at the time when the first polyparaxylylene film 14 is deposited and the position at

which the substrate 10 is supported by the target-support needles 20 at the time when the second polyparaxylylene film 18 is deposited deviate from each other.

Then, the turntable 3c is introduced into the vapor deposition chamber 3, whereas diparaxylylene heated to 175 °C and vaporized in the vaporization chamber 1 and then heated to 690 °C and radicalized in the thermal decomposition chamber 2 is introduced into the vapor deposition chamber 3 from the inlet 3a, whereby the second polyparaxylylene film 18 is deposited on all surfaces of the scintillator 12 and substrate 10 by a thickness of 10  $\mu\text{m}$ . When this step is completed, the making of a scintillator panel 30 ends. This scintillator panel 30 is used as a radiation detector when an unshown imaging device (CCD) is bonded thereto on the scintillator 12 side and X-rays are made incident thereon from the substrate 10 side.

Since the substrate 10 formed with the scintillator 12 is supported only by the tip parts of target-support portions 20a of the sample support needles 20 on the turntable 3c, the contact area between the bottom face of substrate 10 and the tip parts of target-support portions 20a becomes smaller, whereby polyparaxylylene films can uniformly be deposited on the underside of substrate 10 and the like as well in the polyparaxylylene film vapor deposition method in accordance with this embodiment. Also, the substrate 10 can easily be taken up from the turntable 3c after the

first and second polyparaxylylene films 14 and 18 are deposited.

Since the position at which the substrate 10 is supported by the target-support needles 20 at the time when the first polyparaxylylene film 14 is deposited and the position at which the substrate 10 is supported by the target-support needles 20 at the time when the second polyparaxylylene film 18 is deposited are shifted from each other, the first and second polyparaxylylene films 14 and 18 can be prevented from peeling off, and the moisture resistance of scintillator 12 can be improved.

Though the substrate 10 formed with the scintillator 12 is supported by three target-support needles 20 in the above-mentioned embodiment, it may also be supported by four or more target-support needles.

Also, though each target-support needle 20 has a pointed target-support portion 20a at one end and a disk-shaped base portion 20b at the other end in the above-mentioned embodiment, the form of target-support needle 20 can be changed as appropriate as long as it can stably support the substrate 10 on the turntable 3c while yielding a small contact area with the bottom face of substrate 10. For example, the substrate may be supported by a strand member (target-support) 40 as shown in Fig. 6. Since the substrate 10 is supported by at least three protrusions 40a of the strand member 40 in this case as well,

the contact area between the bottom face of substrate 10 and the strand member 40 can be made smaller, whereby the polyparaxylylene film can uniformly be deposited on the underside of substrate 10 and the like as well.

5           Though the  $\text{SiO}_2$  film 16 is used as a transparent inorganic film in the above-mentioned embodiment, it is not restrictive; and inorganic films made from  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{In}_2\text{O}_3$ ,  $\text{SnO}_2$ ,  $\text{MgO}$ ,  $\text{MgF}_2$ ,  $\text{LiF}$ ,  $\text{CaF}_2$ ,  $\text{AgCl}$ ,  $\text{SiNO}$ ,  $\text{SiN}$ , and the like may also be used.

10           Though  $\text{CsI(Tl)}$  is used as the scintillator 12 in the above-mentioned embodiment, it is not restrictive; and  $\text{CsI(Na)}$ ,  $\text{NaI(Tl)}$ ,  $\text{LiI(Eu)}$ ,  $\text{KI(Tl)}$ , and the like may also be used.

15           Though a substrate made of Al is used as the substrate 10 in the above-mentioned embodiment, any substrate can be used as long as it has a favorable X-ray transmissivity, whereby substrates made of amorphous carbon, substrates mainly composed of carbon such as a substrate made of C (graphite), substrates made of Be, substrates made of  $\text{SiC}$ ,  
20           and the like may also be used. Also, substrates made of glass, and FOP (fiber optical plate) may be used.

25           In the above-mentioned embodiment, polyparaxylylene encompasses not only polyparaxylylene but also polymonochloroparaxylylene, polydichloroparaxylylene, polytetrachloroparaxylylene, polyfluoroparaxylylene, polydimethylparaxylylene, polydiethylparaxylylene, and

the like.

According to the organic film vapor deposition method of the present invention, organic films can be deposited on all surfaces of the substrate provided with the scintillator, and the substrate can easily be taken up from the turntable after the organic films are deposited.

From the invention thus described, it will be obvious that the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended for inclusion within the scope of the following claims.